Comment on "Search for Axions with the CDMS Experiment"

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The CDMS collaboration has recently reported new limits on axion-like particles [1], constraining the origin of the DAMA annual modulation effect. It is claimed in [1] that limits from both CDMS and CoGeNT [2] "completely exclude the DAMA allowed region" able to explain the modulation. This is in contrast with [2], where claims of DAMA exclusion are avoided, emphasizing instead a competitive DAMA sensitivity to pseudoscalars. We clarify here this possible source of confusion.

An interpretation of the DAMA modulation based on the axio-electric effect is prompted by the observation of a peak in their spectrum at 3.2 keV, where the modulation is also maximal. A fraction of these events can arise from mundane ^{40}K decays. ^{nat}K is present in DAMA crystals at < 20 ppb, the upper limit being able to explain the total of the ~ 0.75 counts/kg-day under the peak. Several sources of uncertainty lead to a broad allowed region in axio-electric coupling vs. pseudoscalar mass [3].

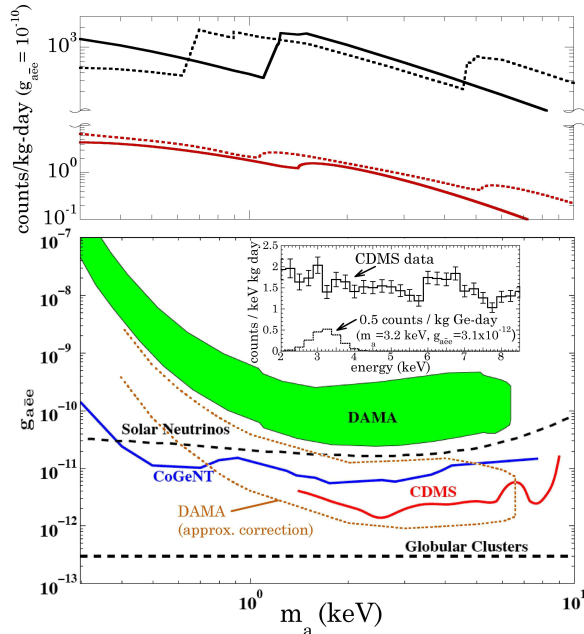Pospelov *et al.* [4] pointed out two intimately related

FIG. 1: Top: Axio-electric rates in germanium (solid) and NaI (dotted). Upper lines follow [4], lower follow [3]. Modern photoelectric cross-sections are used in the first case, a hydrogenic wavefunction approximation in the second. Bottom: Axio-electric exclusion boundaries from CoGeNT and CDMS, also displaying the DAMA allowed region (see text).

flaws in the definition of this allowed region. First, the leading term in the Hamiltonian for the interaction would have been left out in DAMA's derivation of the axio-electric rate [3]. Fig. 1 (top) shows the large differences in rate following the formula in [4] and calculations based on [3]. The ratio of the NaI rates is used to estimate what would have been the correct location of the DAMA allowed region (Fig. 1, bottom). This is the origin for the moderate statements in [2]: while CoGeNT would impose a lower bound $m_a >$0.8 keV, neither CoGeNT nor CDMS would presently exclude all of the phase space allowed for a pseudoscalar interpretation of the DAMA effect.

The second objection in [4] is however more fundamental. General principles are cited that point to a typical $1/v$ dependence for the inelastic scattering cross-section of non-relativistic particles, as is the case here for the correct Hamiltonian. Flux being proportional to v, the interaction rate should be (to first order) velocity-independent, negating the possibility of a modulation large enough to explain DAMA's observations. In this situation it clearly makes no sense to speak of an allowed region. We instead expect the competitive DAMA sensitivity mentioned in [2] (i.e., an exclusion boundary comparable to that from CDMS and CoGeNT). To illustrate the point, the inset in Fig. 1 shows the signal from a pseudoscalar responsible for 50% of the intensity under the 3.2 keV DAMA peak. This is clearly at the limit of detectability for CDMS.

We conclude by noting that it may be possible to recover a source for the modulation and with it the concept of an allowed or favored DAMA region. For instance, if a solar-bound population of dark pseudoscalars is invoked, yearly changes by few percent in interaction rate can arise from velocity-independent considerations: the Earth's orbital ellipticity modulates the phase space of their viable orbits [5], with extrema in early July and January (either sign is possible depending on which orbital invariants are favored by the population). In other words, the modulation would enter via the number density of the particles, not their velocities. A reasonable (i.e., beyond reach of existing bounds) local density for this population would bypass the remaining astrophysical constraints on their coupling (globular clusters, Fig. 1). This possibility illustrates the rich phenomenology available for a dark matter interpretation of the DAMA effect.

and discussion on these issues can be found in [6].

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[2] C.E. Aalseth *et al.*, Phys. Rev. Lett. **101** (2008) 251301.
[3] R. Bernabei *et al.*, Int. J. Mod. Phys. **A21** (2006) 1445.
[4] M. Pospelov *et al.*, Phys. Rev. **D78** (2008) 115012.
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[6] P. Gondolo and G.G. Raffelt, `arXiv:0807.2926v2`.